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Social and economic factors of the natural risk increasing: estimation of the Russian regions

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Abstract. This study is an attempt to assess quantitatively social and economic factors that determine vulnerability of Russian regions to natural risk, to trace the space differences of the considered factors, and to group the regions by their similarity. In order to indicate the regional differences in social and economic development, equipment condition, dangerous substances accumulation, and social trouble four the most suitable parameters were estimated, including the per capita production of Gross Regional Product (GRP), capital consumption, volume of total toxic waste, and crime rate. Increase of the first parameter causes vulnerability reducing, the increase of the last three causes its increasing. Using multidimensional cluster analysis five types of regions were found for Russia according to similarity of the considered parameters. These types are characterized with higher value of a single (rarely two) chosen parameter, which seems to be sufficient enough to affect natural risks increasing in these regions in near future. Only few regions belonging to the fifth type proved to have rather high value of GRP and relatively low values of the other parameters. The negative correlation was found between a number of natural disasters (ND) and the per capita GRP in case when some parameters reached anomalously high value. The distinctions between regions by prevailing different parameters, which result in natural risk increasing, help risk management to find directions where to focus on.

1 Introduction

The past decade witnessed an exponential growth in the occurrence of natural disasters (ND). There were more than 3 400 large-scale ND resulting in death of approximately 800 000 people and causing economic losses in excess of US$ 608 billion, which in fact reflects an annual increase of approximately 10% during the 1990s. Rapidity of increase of affected people is greater than the rapidity of increase of a number of events (United Nations World Disaster Reduction Campaign, 2001). More than 3 680 natural disaster events were recorded in Russia from 1990 to 2002. It gives an annual average number of 283 ND (in the 1980s it was from 110 to 130 ND) (Natural hazards and society, Natural hazards of Russia, 2002). In fact, 91 ND were registered in 1991, while there were 465 ND in 1998 (maximum) and 279 ND in 2002. The ND have killed more than 300 people and affected about 330 000 people in 2002 alone. Forest fires are the most often in Russia (about 30–40% of all ND). Meteorological phenomena, such as hurricanes, windstorms, high winds, and squall constitute is the second contributory factor (28%) and floods represent 19% (State reports of Emergency Ministry of Russia about Protecting Population and Territory of Russian Federation against Natural and Man-Caused ND in 1997–2001, 2002).

Literature dealing with natural hazards, disaster vulnerability, and risk assessment typically represents three categories. Most researchers studied natural hazards in themselves, their physical parameters, distribution, and etc. They identified natural hazards as the cause of vulnerability (scientific and technological approaches). The assumption has been that such events, as acts of nature, cannot be prevented. However, vulnerability could be reduced by avoiding dangerous areas (Natural disasters and vulnerability analysis, 1979). The second group of researchers (economic approach) focuses on the analysis of economic impacts of ND, direct and indirect costs, as well as secondary effects. It attempts to develop economically rational criteria for reducing vulnerability (Anderson, 1990). The third group of investigations (since White, 1973) recognizes the differential character of vulnerability and the central role of the human (or society as a whole) in creating vulnerability (social approach). Economic poverty, social and political marginalization, lack of options, as well as lack of resources, and other social, economic, and political indicators are included (Anderson, 1995).

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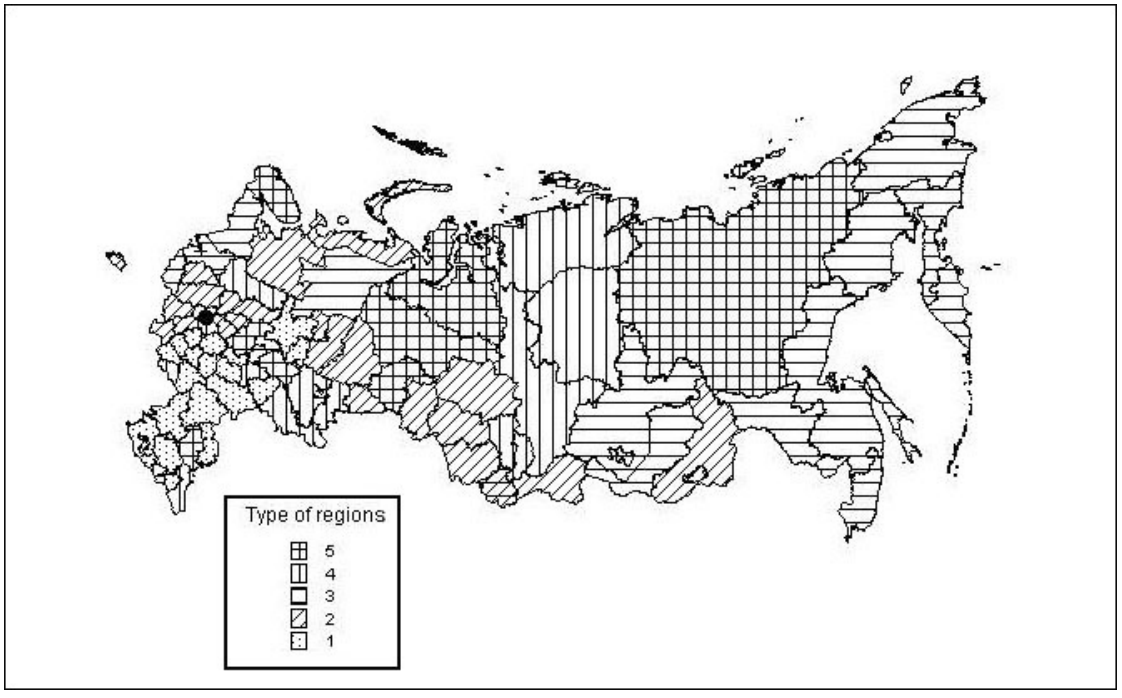

Fig. 1. Types of the Russian regions with similar values of the parameters.

More recent studies propose an integrated approach to natural risk assessment. Disaster is seen as social and economic phenomenon rather than geophysical and technical one (Global Change, 1991). So Myagkov and Kozlov (1993) ranked among the natural risks factors, such as social and psychological aspects, land-use experience, population density, technological complexity of production and communication, concentration of industrial capacities, especially, of hazardous plants. Myagkov (2001) emphasized ethnic and cultural features of population, such as inclination to risk, attitude to fate (as controlled or unavoidable), individual risk assessment, and response. According to (Natural Disasters in the World, Statistical Trend on Natural Disasters, 1994), interdependence between per capita Gross Domestic Product (GDP) and a number of ND for countries all over the world was found. In a framework for assessing vulnerability Anderson (1995) suggested including the four steps: 1) identifying hazards, 2) identifying exposure, 3) identifying the complex sources of the hazard, and 4) time and space dimensions. Weichselgartner and Bertens (2000) propose to synthesize both the physical and social factors. Along with hazard and exposure, in their concept such factors as preparedness, prevention, and response are considered. The result is a vulnerability map, where not only degree but also causes of vulnerability are given (hazard-of-place approach).

We believe (Petrova, 2002) that vulnerability also depends on economy type (industrial or agricultural), on region structure and dimensions, as well as on activity of economic relations between regions. The uniqueness of the objects within any region as well as the uniqueness of the region itself (residence areas of small and indigenous nations, areas with unique natural environment, and others) increases its vulnerability.

This study is an attempt to assess quantitatively social and economic factors that determine vulnerability of Russian regions to natural risk, to trace space differences of the considered factors, and to group the regions by their similarity.

2 Research region and methods

The level of administrative units of the Russian Federation (RF) was chosen for the research because comparable statistical data for the administrative units are available for assessment. The first step of the study was a selection of parameters for assessing social and economic conditions of the Russian regions, which affect vulnerability to ND. We have taken only four parameters that could better indicate the regional differences in social and economic development, equipment condition, dangerous substances accumulation, and social troubles. In our choice we were restricted by availability of official statistical data.

- The per capita production of Gross Regional Product (GRP) is the most informative economic parameter describing differences of the social and economic conditions of the regions, which in turn determine available material resources for vulnerability reducing.
- Wear and tear of equipment as well as social and industrial infrastructure including travel facilities essentially increases vulnerability. A statistical parameter for depreciation of assets (capital consumption) was taken for appropriate calculation.

Table 1. Average values of the parameters and a number of ND for the region types.

Type of Regions	Per capita GRP, US$		Capital consumption, %		Volume of toxic waste, thousand tons		A number of crimes per 100 000 people		A number of ND per 1 000 people	
1	4 761	L	47.2	H	1 798	L	1 613	L	0.37	L
2	4 457	L	45.5	H	1 720	L	2 475	H	0.27	L
3	4 769	L	36.5	AL	1 941	L	2 506	H	0.89	H
4	6 108	H	40.8	L	20 174	AH	1 685	L	0.14	L
5	11 301	AH	39.9	L	1 402	L	1 814	L	0.3	L
Total	5 449		42.8		4 333.6		2 073		0.42	

The parameters in Table 1 are ranked as follows: AL – anomalously low, L – low, H – high, AH – anomalously high.

- The highest risk results from destruction probability by natural hazards for radiation-dangerous units and storage of toxic and radioactive waste. Since the data of radioactive waste accumulation are not available, volume of toxic waste was taken.

- The regions with unfavorable social situation are more vulnerable. Criminality level was taken as an indicator of social troubles.

Data concerning the above-mentioned parameters were taken from the statistical yearbook Regions of Russia, 2001.

As the second step, average values and standard deviations of every taken parameter were calculated for all the regions. Then the values of each parameter in all the regions were classified in comparison with average ones. The values, which are higher (lower) than the average ones, were considered as high (low). The results differed from average values for more than the standard deviation were considered as anomalous ones.

The third step of the study was multidimensional cluster analysis (software package Gold-Geochemist) for all the 89 Russian regions by all taken parameters. This method permits us to group objects (regions) with similar values of the parameters. Afterwards the average values of every taken parameter were calculated for each group.

Finally the correlation analysis for relations between annual average number of ND (per 1000 people) and the per capita production of GRP was done. Data concerning a number of ND were taken from the State Reports of the Emergency Ministry of the Russian Federation. For the administrative units such data are available only for 1997–2002. The coefficient of correlation was calculated for the totality of regions as well as for the groups with anomalously high values of the parameters.

3 Results

Majority regions of Russia (51 of 79 for whom the State Statistic Committee calculated this parameter) are characterized with the per capita GRP lower than the average one (US$ 5 449 if to take into account purchasing-power parity). Three regions among these 51 (Tyva, Ingushetia, and Dagestan Republics) have anomalously low value of the parameter (less than US$ 2 251). 23 regions have high value. Five regions only (Tyumen Region, Moscow, Krasnoyarsk Territory, and the Republics of Tatarstan and Komi) have anomalously high per capita GRP (more than US$ 9 500).

In 50 regions the capital consumption exceeds 42.8% (average value). Moreover, it is more than 48.4% (anomalously high) in Novosibirsk, Penza, Kirov, Postov, Kursk, Yaroslavl, Samara, Volgograd Regions, and in the Republic of Ingushetia. Equipment aging is the most catastrophic in case of chemical, petrochemical, and oil-processing industry, including gas and oil pipelines. Capital consumption reached in Russia 70% for the oil refineries, from 70 to 80% for railway facilities, 72% for pipelines, and 75% for housing utilities and services (State reports of Emergency Ministry of Russia about Protecting Population and Territory of Russian Federation against Natural and Man-Caused ND in 1997–2001, 2002).

Storing and processing toxic waste are under statistical observation in Russia since 1994. We estimated toxic waste stored in the regions from 1994 to 1999. Anomalously high volumes of toxic waste (more than 13 million tons) were accumulated during this period in Republic Bashkartostan (Bashkiria), Orenburg, Chelyabinsk, Kemerovo, Vologda Regions, and Krasnoyarsk Territiory. 12 regions have high values of the parameter (more than 4333.6 tons). The more toxic waste is in a region, the higher is disaster probability with fatal consequences in case of natural hazard impact on such waste stores.

Anomalously high criminality level (more than 2600 registered crimes per 100 000 people) was marked in Kurgan, Perm, Leningrad, Novosibirsk, Tyumen, Irkutsk, and Magadan Regions, as well as in Buryatia, Jewish Autonomous Area, and Khabarovsk Territory. 29 regions have high values of the parameter (more than 2073). Of course, negative social conditions do not influence directly on occurrence of natural hazards. Nevertheless, strengthening social troubles

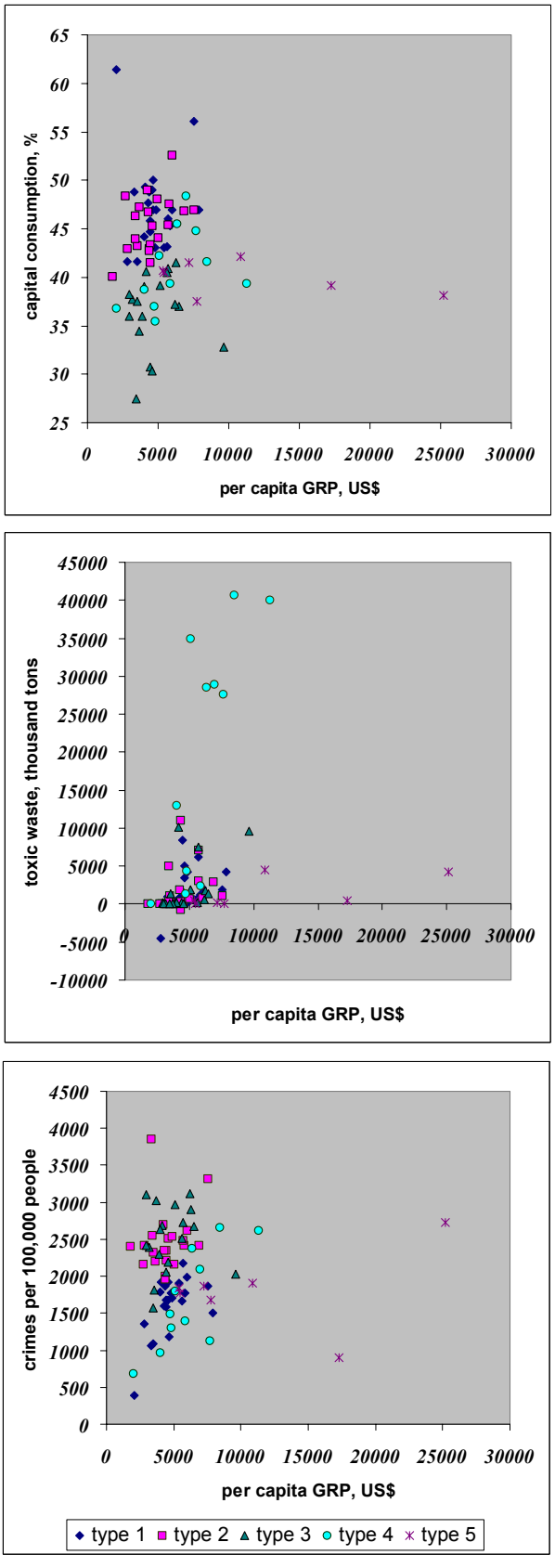

Fig. 2. Relation of the social and economic parameters for different types of regions.

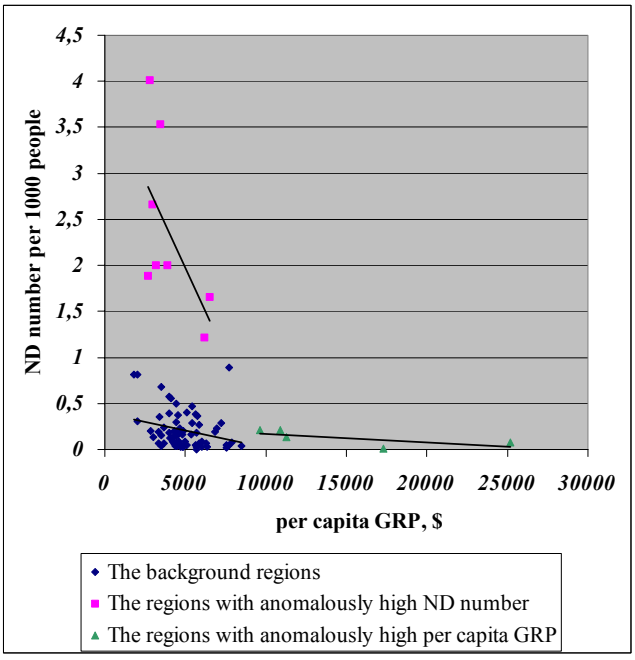

Fig. 3. Dependence between the per capita production of GRP and a number of ND per 1000 people.

lead to increasing both disaster seriousness and so called "human factor", possibility of man-caused disasters (due to unpremeditated actions, sabotage, or acts of terrorism).

Using multidimensional cluster analysis five types of regions were found for RF according to the similarity of the above-mentioned parameters that permitted us to create a map (Fig. 1). The difference between these types is distinctly shown on the graphs (Figs. 2a–c). The main characteristics of the types are shown in Table 1. These types are characterized with higher value of a single (rarely two) parameter.

- The first type of regions (22 regions) is generally characterized with high and anomalously high capital consumption and low per capita GRP.
- The second type includes 21 regions and is characterized with both high capital consumption and high criminality level, and low per capita GRP.
- The third type is marked with the highest criminality level and low per capita GRP. 18 regions of this type have also the highest quantity of ND per 1000 people.
- 11 regions of the forth type are characterized with high volumes of toxic waste and per capita GRP.
- 7 regions of the fifth type are the most successful from all points of view. They are characterized with both high per capita GRP and relatively low values of all parameters increasing natural risk.

Table 1 also shows data concerning an annual average number of ND per 1000 people. Analyzing the table one can note inverse relation between the per capita GRP and a number of ND for three region types. For example, high (the forth type) and anomalously high (the fifth type) per capita GRP corresponds to a low ND number. One of the types (the third one) has low per capita GRP value and simultaneously high ND quantity. At the same time the first and the second types have low values of both per capita GRP and a number of ND. It shows rather a complex character of the relation. In general, there is a trend to ND number reducing if per capita GRP increases (Fig. 3). In principle, this dependence is similar with that between per capita GDP and a number of ND on the international level (Natural Disasters in the World, Statistical Trend on Natural Disasters, 1994). However, the coefficient of correlation for the totality of regions is too low (–0.21). That is why we tried to find out more precise structure of this correlation.

As the Fig. 3 shows this interdependence is watched more distinctly in those regions, where either per capita GRP or a number of ND are anomalously high. In the first case the coefficient of correlation is –0.69 and in the second case it is –0.61. The rest of the regions have the coefficient of correlation –0.27. Anomalously high annual average number of ND is marked in the Republics of Karachai-Cherkess, Adygei (the Northern Caucasus), and Altai (the West Siberia), in Chukchi, Koryak, and Jewish Autonomous Areas, as well as in Amour and Sakhalin Regions and Khabarovsk Territory (the Far East). The relatively small increase of the per capita GRP corresponds to sharp reducing a number of ND in this group. The above-mentioned regions with anomalously high values of the per capita GRP have simultaneously low and anomalously low ND number. One can assume that this relationship is a result of reducing vulnerability after the per capita GRP has exceeded a certain level.

4 Discussion and perspectives

In generally the results of the presented study corroborate the assumption that the social and economic factors have a certain influence on natural risks increasing (or decreasing). More distinctly it is shown in the negative correlation between the per capita production of GRP and a number of ND. However, we have found this interdependence to have more complex structure. So this relation is more intimate in those regions, where either per capita GRP or a number of ND are anomalously high. Of course, the analysis will be continued. For instance, it needs to be extended for longer period of ND observation. The background group of regions, which is heterogeneous in regard to this correlation, requires the special attention. The other parameters could be also taken into account.

Using multidimensional cluster analysis five types of Russian regions were found by the similarity of the taken parameters. It is interesting that every group is characterized with a single (rarely two) prevailing factor resulting in nature risk increasing: high or anomalously high values of capital consumption, toxic waste, and crime rate with simultaneously low values of GRP. It seems to be sufficient enough to affect increase of a number and seriousness of ND in these regions in near future. Only few regions belonging to the fifth type proved to have relatively low values of the three parameters and rather high values of GRP. The analysis permitted us to create a map that shows differences in prevailing risk factor for the region types, which help risk management to find directions where to focus on. That is the main difference between the proposed approach and the approach based on calculation of an average indicator of vulnerability (Weichselgartner and Bertens, 2000). In future the distinctions of the both methods should be taken into account for problem statement. For example, it is interesting to compare the both approaches by creating maps for the same area.

This study is the first attempt of such an analysis for the Russian regions. In future contribution of the other social and economic factors as well as nature peculiarities should be investigated. The seriousness of disasters, the various types of natural hazards should be considered.

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